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PATENT APPLICATION

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SUSUMU YASUDA, et al.	)	
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SUBMISSION OF SWORN TRANSLATION OF PRIORITY DOCUMENT

Sir:

Further to the Response To Office Action dated November 1, 2006, Applicants submit herewith a sworn translation of priority application Japan 2003-089465, filed on March 28, 2003. In accordance with MPEP § 201.15, the Examiner is requested to confirm that Applicants are entitled to the March 28, 2003 priority date. Once the Examiner makes such a determination, the Examiner is respectfully requested to remove U.S. Patent No.6,965,239 (Yasuda) as a reference against each of the rejected claims supported by the sworn translation.

Applicants' undersigned attorney may be reached in our Costa Mesa, California office at (714) 540-8700. All correspondence should continue to be directed to our below-listed address.

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DECLARATION

I, Shinichi Usui, a Japanese Patent Attorney registered No. 9694, of Okabe International Patent Office at No. 602, Fuji Bldg., 2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo, Japan, hereby declare that I have a thorough knowledge of Japanese and English languages, and that the attached pages contain a correct translation into English of the priority documents of Japanese Patent Application No. 2003-089465 filed on March 28, 2003 in the name of CANON KABUSHIKI KAISHA.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made, are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

signed this 30th day of November, 2006

Shinichi Usui

PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: March 28, 2003

Application Number: Japanese Patent Application No. 2003-089465 [JP2003-089465]

Applicant(s): CANON KABUSHIKI KAISHA

April 28, 2004

Commissioner,
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[Title of the Invention]	Potential Sensor and Image Forming Apparatus
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[Title of the Invention] Potential Sensor and Image Forming Apparatus

[Claim(s)]

[Claim 1] A potential sensor comprising first and second detection electrodes opposed to a potential-measured object of which a potential is to be measured, a movable shutter so positioned between said detection electrodes and said potential-measured object with gaps thereto when said two sets of detection electrodes are opposed to the potential-measured object, and differential processing means for differentially processing output from said first and second detection electrodes;

wherein said movable shutter can assume a first state and a second state, said first detection electrode is exposed to the potential-measured object wider when said movable shutter assumes the first state than when said movable shutter assumes the second state, and said second detection electrode is exposed to the potential-measured object narrower when said movable shutter assumes the first state than when said movable shutter assumes the second state.

[Claim 2] The potential sensor according to claim 1, comprising a substrate, first and second detection electrode assemblies of which at least either one is formed in plural parts and which are provided on said

substrate, and at least one movable shutter on said two sets of the detection electrode assemblies with a gap thereto, wherein said first detection electrode assembly is exposed to a potential-measured object wider when said movable shutter assumes a first state than when said movable shutter assumes a second state, and said second detection electrode assembly is exposed to the potential-measured object narrower when said movable shutter assumes the first state than when said movable shutter assumes the second state.

[Claim 3] The potential sensor according to claim 1 or 2, wherein said movable shutter is elastically supported movably between the first state and the second state.

[Claim 4] The potential sensor according to claim 3, wherein a drive frequency of said potential sensor is substantially equal to a mechanical resonance frequency of said movable shutter.

[Claim 5] The potential sensor according to any one of claims 1 to 4, wherein said movable shutter is so constituted as to be controlled by a magnetic field generation means which generates a magnetic field substantially perpendicularly to a movable direction of said movable shutter and a current application means which supplies said movable shutter with a current substantially perpendicularly to the movable direction of said movable shutter and to a direction of said

magnetic field, thereby assuming said first state and said second state.

[Claim 6] The potential sensor according to claim 5, wherein said magnetic field generation means is a permanent magnet or an electromagnetic coil.

[Claim 7] The potential sensor according to any one of claims 1 to 4, comprising two or more movable shutters and at least two current application means which supplies said movable shutters with currents substantially perpendicularly to the moving directions of said movable shutter, whereby said first state and said second state can be assumed by an interaction of the currents supplied to said movable shutters.

[Claim 8] An image forming apparatus comprising a potential sensor according to any one of claims 1 to 7 and an image forming means which controls an image formation based on an output of said potential sensor.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a potential sensor of non-contact type which can be easily prepared by a MEMS (micro electro mechanical systems) technology, and an image forming apparatus and a potential measuring method utilizing such potential sensor.

[0002]

[Prior Art]

As a sensor for measuring a surface potential of a measured object, there is already known a variable capacitance potential sensor of mechanical type. Fig. 9 shows a principle of the variable capacitance potential sensor of mechanical type. A measured object 1099 has a potential V relative to a ground potential. A detection electrode 1021 is provided in an opposed relationship thereto, and a movable shutter 1025 is provided immediately above the detection electrode 1021. When the movable shutter 1025 moves, an electrostatic capacitance C between the measured object 1099 and the detection electrode 1025 shows a variation. In the detection electrode 1021, a charge Q is induced according to V and C. A current flowing between the detection electrode 1021 and the ground is detected by an ammeter 1060. As the charge Q induced in the detection electrode 1021 is given by Q = CV, a current flowing in the ammeter 1060 at a time t is given by i = dQ/dt = VdC/dt, and the potential V can be obtained if dC/dt is known. The dC/dt is a sensitivity of this sensor, and, as will be apparent from this relation, the sensitivity can be elevated by increasing the difference between the maximum and minimum values of C or reducing the time t of variation.

[0003]

Such variable capacitance potential sensor of

mechanical type, obtainable with the MEMS technology, is for example known in a following type (cf. Patent Document 1). Fig. 10 illustrates a potential sensor 1001, which is constituted by a driver component 1010 and a sensor component 1020. These components can be prepared by the MEMS technology on a substrate 1004.

[0004]

The driver component 1010 is formed by a suspension 1018 having a parallel hinge structure, and a comb-shaped electrostatic actuator 1012. The comb-shaped electrostatic actuator 1012 is a common mechanism for electrostatically driving a micro structure, and is constituted by a movable electrode 1013 supported by the suspension 1018 and a fixed electrode 1014 mounted on the substrate 1004. The comb-shaped electrostatic actuator 1012 is electrically connected to an electrostatic drive signal source 1050. The movable electrode 1013 is supported by the suspension 1018 so as to be movable in a lateral direction in the drawing. The comb-shaped electrodes of the movable electrode 1013 and those of the fixed electrode 1014 are mutually meshing and an electrostatic attractive force is exerted therebetween when a potential difference is given.

[0005]

The driver component 1010 is connected to the sensor component 1020. A detection electrode assembly

1021 is fixed to the substrate 1004 and is capable of a capacitative coupling with a measured surface. The detection electrode assembly 1021 is constituted by a set of mutually separated individual detection electrodes (represented by 1021a, 1021b, 1021c). Individual detection probes are connected together, so that the individual signals are combined (superposed). The sensor component 1020 is further provided with a movable shutter 1025, which selectively covers the detection electrode assembly 1021. The movable shutter 1025 is mechanically connected to the driver component 1010, of which a linear displacement induces a corresponding displacement of the movable shutter 1025.

[0006]

The movable shutter 1025 is provided with plural apertures 1024, which are so constructed as to selectively expose the detection electrode assembly 1021 through the apertures 1024 when the movable shutter 1025 is in a first position. The apertures 1024 are mutually separated by a distance corresponding to a distance between the detection electrodes. When the movable shutter 1025 is in a second position, the detection electrode assembly 1021 is covered by mask portions 1026 present between the apertures 1024. Stated differently, when the movable shutter 1025 is in the first position, the capacitative coupling by the detection electrode assembly 1021 is enabled. On the

other hand, when the movable shutter 1025 is in the second position, the detection electrode assembly 1021 is masked and prevented from the capacitative coupling. A current generated in the detection electrode assembly is outputted to a lead electrode 1028 and is amplified by an amplifier 1060.

[0007]

[Patent Document 1]

Japanese Patent Application Laid-Open No. 2000-147035

[0008]

[Problem to be Solved by the Invention]

However, the aforementioned MEMS electrostatic sensor has the following problems.

1. An effective area of the detection electrode cannot be made large. Because the detection sensitivity dC/dt of the electrostatic sensor is proportional to the effective area of the detection electrodes, the detection sensitivity cannot be made sufficiently high. This will be explained using Fig. 11. Fig. 11 is a cross-sectional view along a line 1080 in Fig. 10. As clearly shown in Fig. 11, a width W1 of individual detection electrodes constructing a detection electrode assembly 1021 must be arranged respectively so as to be separated with an interval for a size W2 equivalent to the interval of each shutter aperture 1024. Consequently, widths W1 and W2 are almost equal to each

other so that the effective area of the detection electrodes has been limited to about a half of an occupied area on the substrate.

[0009]

2. In addition, in the conventional MEMS electrostatic sensor, the driver component 1010 and the sensor component 1020 are formed at different places on the substrate 1004, so disregarding their arrangements, chip size tends to be bigger. This limits compactization of the MEMS electrostatic sensor and increases the costs.

[0010]

3. Since the driver component 1010 and the sensor component 1020 move integrally, the weight of the movable portion becomes larger, which makes it difficult to increase the drive frequency. Since the detection sensitivity dC/dt of the electrostatic sensor is also proportional to the drive frequency, the detection sensitivity cannot be larger.

[0011]

4. For the MEMS electrostatic sensor of the type which uses an electrostatic actuator 1012, high voltage is required to drive and this makes the driver high cost.

[0012]

In consideration of the aforementioned situation, the present invention aims at providing a non-contact

type potential sensor having the structure which can solve at least the problem of 1. among these problems and an image forming apparatus which uses this potential sensor.

[0013]

[Means for Solving the Problem]

A potential sensor according to the present invention to achieve the above-mentioned object is a potential sensor comprising first and second detection electrodes opposed to a potential-measured object of which a potential is to be measured, a movable shutter so positioned between the detection electrodes and the potential-measured object with gaps thereto when the two sets of detection electrodes are opposed to the potential-measured object, and differential processing means for differentially processing output from the first and second detection electrodes, wherein the movable shutter can assume a first state and a second state, the first detection electrode is exposed to the potential-measured object wider (typically, exposed to almost whole surface) when the movable shutter assumes the first state than when the movable shutter assumes the second state, and the second detection electrode is exposed to the potential-measured object narrower (typically, masked almost whole surface) when the movable shutter assumes the first state than when the movable shutter assumes the second state. Such

configuration allows to increase the effective area of the detection electrodes since the first and second detection electrodes can be positioned closer, and to increase the sensitivity for a given size, as a signal is obtained by a differential processing of outputs of the electrodes. Also it can be realized in a smaller size for a same sensitivity, thus allowing a compact structure and a cost reduction.

[0014]

The potential sensor preferably comprises a substrate, first and second detection electrode assemblies of which at least either one is formed in plural parts and which are provided on the substrate, and at least one movable shutter on the two sets of the detection electrode assemblies with a gap thereto, wherein the first detection electrode assembly is exposed to a potential-measured object wider when the movable shutter assumes a first state than when the movable shutter assumes a second state, and the second detection electrode assembly is exposed to the potential-measured object narrower when the movable shutter assumes the first state than when the movable shutter assumes the second state. Though each of the first and second detection electrodes may be formed by a single part, the structure of such configuration allows to further increase the effective area of each detection electrode.

[0015]

In the potential sensor, the movable shutter is preferably elastically supported movably between the first state and the second state. Thereby there can be realized a movement of the movable shutter not hindered by a friction. A drive frequency of the potential sensor is preferably substantially equal to a mechanical resonance frequency of the movable shutter. Thereby an electric power consumption for obtaining a given amplitude can be significantly reduced.

[0016]

In the potential sensor, the movable shutter is preferably so constituted as to be controlled by a magnetic field generation means which generates a magnetic field substantially perpendicularly to a movable direction of the movable shutter and a current application means which supplies the movable shutter with a current substantially perpendicularly to the movable direction of the movable shutter and to a direction of the magnetic field, thereby assuming the first state and the second state. The magnetic field generation means is preferably a permanent magnet or an electromagnetic coil. Such configuration, in which the movable shutter itself comprises a part of an actuator, does not require preparation of a separate actuator unit and can therefore be realized compactly. Also in case plural movable shutters are provided, each movable

shutter can be operated individually, thereby reducing the mass of a movable part and increasing the operating speed to elevate the sensitivity of the sensor. Also the driver can be realized with a lower cost as a high voltage is not required in driving.

[0017]

The potential sensor preferably comprises two or more movable shutters and at least two current application means which supplies the movable shutters with currents substantially perpendicularly to the moving directions of the movable shutter, whereby the first state and the second state can be assumed by an interaction of the currents supplied to the movable shutters. Since the movable shutter itself comprises a part of an actuator also in this configuration, a separate actuator unit need not be prepared and a compact configuration can be realized. Also since each movable shutter can be operated individually, it is possible to reduce the mass of a movable part and to increase the operating speed thereby elevating the sensitivity of the sensor. Also the driver can be realized with a lower cost as a high voltage is not required in driving.

[0018]

An image forming apparatus according to the present invention to achieve the above-mentioned object is provided comprising the potential sensor and an

image forming means which controls an image formation based on an output of the potential sensor. Such configuration allows to provide an image forming apparatus exploiting the features of the potential sensor. The image forming means has, for example, a copying function, a printing function or a facsimile function. Also the image forming means can be realized in a configuration including a photosensitive drum, in which a charged potential of the photosensitive drum is measured by the aforementioned potential sensor provided in an opposed relationship to the photosensitive drum.

[0019]

[Embodiment(s)]

In the following, in order to clarify embodiments of the present invention, specific examples will be explained with reference to accompanying drawings.

[0020]

(Example 1)

Fig. 1 is a plan view of a potential sensor of Example 1, and Fig. 2 shows cross-sectional views thereof. A potential sensor 101 is formed by a driver component 110 and a sensor component 120. These are formed by a MEMS technology on a substrate 104.

[0021]

The driver component 110 is formed by a suspension 118 having a parallel hinge structure, and a comb-

shaped electrostatic actuator 112. The comb-shaped electrostatic actuator 112 is a common mechanism for electrostatically driving a micro structure, and is composed of a movable electrode 113 supported by the suspension 118 and a fixed electrode 114 mounted on the substrate 104. The comb-shaped electrostatic actuator 112 is electrically connected to an electrostatic drive signal source 150. The movable electrode 113 is supported by the suspension 118 so as to be movable in a lateral direction in the drawing. The comb-shaped electrodes of the movable electrode 113 and those of the fixed electrode 114 are mutually meshing and an electrostatic attractive force is exerted therebetween when a potential difference is given. This structure is same as in the prior potential sensor explained in the foregoing.

[0022]

The driver component 110 is connected to the sensor component 120. Detection electrode assemblies 121a, 121b featuring the present example are fixed to the substrate 104, and each is capable of a capacitative coupling with a surface to be measured. The detection electrode assemblies 121a, 121b are comprised of sets of mutually distanced individual detection electrodes. The detection electrodes of each set are electrically connected. Also the individual detection electrodes of the detection electrode

assemblies 121a, 121b are arranged with such gaps as not to cause electrical shortcircuiting.

[0023]

A movable shutter 125 selectively covers the detection electrode assemblies 121a, 121b. The movable shutter 125 is mechanically connected to the driver component 110, of which a linear displacement induces a corresponding displacement of the movable shutter 125.

[0024]

The movable shutter 125 is provided with plural apertures 124. When the movable shutter 125 is in a first position (a position moved to the right in Fig.1), the detection electrode assembly 121a is exposed through the apertures 124, while the detection electrode assembly 121b is masked (cf. (a) of Fig. 2). Also when the movable shutter 125 is in a second position (a position moved to the left in Fig.1), the detection electrode assembly 121a is masked, while the detection electrode assembly 121b is exposed through the apertures 124 (cf. (b) of Fig. 2).

[0025]

Stated differently, when the movable shutter 125 is in the first position, the detection electrode assembly 121a forms a capacitative coupling with a measurement object, and, when the movable shutter 125 is in the second position, the detection electrode assembly 121b forms a capacitative coupling with the

measurement object. Currents generated by the detection electrode assemblies 121a, 121b are respectively outputted to lead electrodes 122a, 122b and are subjected to a differential amplification by a differential amplifier 160 to provide a sensor output.

[0026]

In the aforementioned configuration, it is possible, by selecting the drive frequency of the movable shutter 125 substantially same as a mechanical resonance frequency, to reduce an electric power required for driving thereby alleviating the burden of the driver component 110.

[0027]

In the present example, as the detection electrode assemblies 121a, 121b are arranged with small gaps on the substrate 104, an effective area of the detection electrodes can be approximately doubled in comparison with the prior potential sensor utilizing the MEMS technology. It is therefore possible to improve the sensitivity for a same dimension as in the prior technology, or to reduce the dimension for a same sensitivity as in the prior technology. It is also possible to reduce the production cost by increasing a number of sensors per a silicon wafer.

[0028]

(Example 2)

Fig. 3 is an exploded perspective view of a

potential sensor of an example 2. On a substrate 204, detection electrode assemblies 221a, 221b, lead electrodes 222a, 222b for detection electrodes, and driving lead electrodes 233a, 233b are formed by patterning. The detection electrode assemblies 221a, 221b are comprised of sets of mutually distanced individual detection electrodes, and the detection electrodes of each set are electrically connected by the lead electrode 222a or 222b for the detection electrodes. Also the individual detection electrodes of the detection electrode assemblies 221a, 221b are arranged with such gaps as not to cause electrical shortcircuiting. Movable shutter units 210a to 210d are formed by mask members 211a to 211d, parallel hinge suspensions 212a to 212d and fixed members 213a to 213d, which are integrally formed with conductive materials. In the present example, the driving lead electrodes 223a, 223b are fixedly coupled with the fixed members 213a to 213d. The mask members 211a to 211d are supported by the parallel hinge suspensions 212a to 212d on the detection electrode assemblies 221a, 221b with a gap thereto. Under the substrate 204, a permanent magnet 230 is positioned to generate a magnetic flux in a direction perpendicular to the substrate 204. The driving lead electrodes 223a, 223b are electrically connected to a driver 250, while the lead electrodes 222a, 222b for the detection electrodes

are electrically connected with a differential amplifier 290.

[0029]

Now the function of the potential sensor of the above-described configuration will be explained. Fig. 4 is a plan view of the present example. A measured object is positioned in a substantially perpendicular direction opposed to the substrate 204. In such state, when a current 841 is generated from the driver 250 as shown in (a) of Fig. 4 and is made to flow from the driving lead electrode 223a to 223b through the movable shutter units 210a to 210d, because of the presence of a magnetic field by permanent magnet 230 in a direction from the reverse side of the plane of the drawing to the observe thereof, the parallel hinge suspensions 212a to 212d are bent and the mask members 211a to 211d move to the right in the drawing. As a result, the detection electrode assembly 221a is exposed to increase an electrostatic capacitance with the measurement object, while the detection electrode assembly 221b is masked to decrease an electrostatic capacitance with the measurement object.

[0030]

Inversely, when a current is made to flow, as shown in (b) of Fig. 4, in a direction from the driving lead electrode 223b to 223a, the mask members 211a to 211d move to the left in the drawing. As a result, the

detection electrode assembly 221b is exposed to increase an electrostatic capacitance with the measurement object, while the detection electrode assembly 221a is masked to decrease an electrostatic capacitance with the measurement object. By repeating the above-described operations, charges of opposite phases are induced in the detection electrode assemblies 221a, 221b and are subjected to a differential amplification by the differential amplifier 290, whereby the potential of the object can be measured.

[0031]

At this time, it is possible, by selecting the drive frequency of the movable shutter units 210a to 210d substantially equal to a mechanical resonance frequency, to reduce an electric power required for driving.

[0032]

Also in the present example, it is possible to increase the area of the detection electrodes. It is therefore possible to improve the sensitivity for a same dimension as in the prior technology, or to reduce the dimension for a same sensitivity as in the prior technology. It is also possible to reduce the production cost by increasing a number of sensors per a silicon wafer.

[0033]

Also the present example, since the movable shutter itself comprises a part of an actuator, does not require preparation of a separate actuator unit and can therefore be realized compactly. It is therefore possible to improve the sensitivity for a same dimension as in the prior technology, or to reduce the dimension for a same sensitivity as in the prior technology. It is naturally possible also to reduce the production cost by increasing a number of sensors per a silicon wafer.

[0034]

Also since each movable shutter moves individually, it is possible to reduce the mass of the movable part and to increase the operation speed, thereby improving the sensitivity. Also, in comparison with Example 1, a high voltage is not required for driving, so that the driver can be realized with a lower cost.

[0035]

(Example 3)

Fig. 5 is an exploded perspective view of a potential sensor of an example 3. On a substrate 304, detection electrode assemblies 321a, 321b, lead electrodes 322a, 322b for detection electrodes, connecting electrodes 323a to 323c, and driving lead electrodes 324a, 324b are formed by patterning. The detection electrode assemblies 321a, 321b are comprised

of sets of mutually distanced individual detection electrodes, and the detection electrodes of each set are electrically connected by the lead electrode 322a or 322b for the detection electrodes. Also the individual detection electrodes of the detection electrode assemblies 321a, 321b are arranged with such gaps as not to cause electrical shortcircuiting. Movable shutter units 310a to 310d are formed by mask members 311a to 311d, parallel hinge suspensions 312a to 312d and fixed members 313a to 313d, which are integrally formed with conductive materials. The connecting electrodes 323a to 323c and the driving lead electrodes 324a, 324b are fixedly coupled with the fixed members 313a to 313d. The mask members 311a to 311d are supported by the parallel hinge suspensions 312a to 312d on the detection electrode assemblies 321a, 321b with a gap thereto. The movable shutter units 310a to 310d are electrically serially connected through the connecting electrodes 323a to 323c and the driving lead electrodes 324a, 324b.

[0036]

Under the substrate 304, a coil substrate 361 is provided. A flat coil 362 is formed by patterning on the coil substrate 361, and a coil driver 363 supplies the flat coil 362 with a current to generate a magnetic flux in a direction perpendicular to the substrate 304. The driving lead electrodes 324a, 324b are electrically

connected to a driver 350, while the lead electrodes 322a, 322b for the detection electrodes are electrically connected with a differential amplifier 390.

[0037]

Now the function of the potential sensor of the present example will be explained. Fig. 6 is a plan view of the present example. A measured object is positioned in a substantially perpendicular direction to the substrate 304. When a current is generated from the driver 350 as shown in (a) of Fig. 6 and is made to flow from the driving lead electrode 324a to 324b, because of the presence of a magnetic field in a vertically upward direction with respect to the plane of the drawing, the mask members 311a and 311c move to the left in the drawing, while the mask members 311b and 311d move to the right in the drawing. As a result, the detection electrode assembly 321b is exposed to increase an electrostatic capacitance with the measurement object, while the detection electrode assembly 321a is masked to decrease an electrostatic capacitance with the measurement object.

[0038]

Inversely, when a current is made to flow, as shown in (b) of Fig. 6, in a direction from the driving lead electrode 324b to 324a, the mask members 311a and 311c move to the right in the drawing, while the masks

members 311b and 311d move to the left in the drawing. As a result, the detection electrode assembly 321a is exposed to increase an electrostatic capacitance with the measurement object, while the detection electrode assembly 321b is masked to decrease an electrostatic capacitance with the measurement object. By repeating the above-described operations, charges of opposite phases are induced in the detection electrode assemblies 321a, 321b and are subjected to a differential amplification, whereby the potential of the measured object can be measured.

[0039]

It is possible, by selecting the drive frequency of the movable shutter units 310a to 310d substantially equal to a mechanical resonance frequency, to reduce an electric power required for driving.

[0040]

The present example can also provide effects similar to those of Example 2. Also the entire structure can be made thin by dispensing with the permanent magnet.

[0041]

(Example 4)

Fig. 7 illustrates an example 4. Detection electrode assemblies 421a, 421b and movable shutter units 410a to 410d are structured similarly as in

Example 3.

[0042]

As shown in Figs. 7(a) and 7(b), the movable shutter units 410a and 410c are electrically serially connected to a driver 450a, while the movable shutter units 410b and 410d are electrically serially connected to a driver 450b.

[0043]

When the drivers 450a, 450b generate currents in a direction shown in (a) of Fig. 7, a current in an upward direction in the drawing flows in the movable shutter units 410a and 410d while a current in a downward direction in the drawing flows in the movable shutter units 410b and 410c. Since currents flowing in a same direction cause a mutual repulsion while currents flowing in opposite directions cause a mutual attraction, the mask members 411a and 411c move to the left in the drawing while the mask members 411b and 411d move to the right in the drawing. As a result, the detection electrode assembly 421a is masked while the detection electrode assembly 421b is exposed.

[0044]

Also when the direction of the current generated by the driver 450b is inverted as shown in (b) of Fig. 7, a current in an upward direction in the drawing flows in the movable shutter units 410a and 410b while a current in a downward direction in the drawing flows

in the movable shutter units 410c and 410d. Since currents flowing in a same direction cause a mutual repulsion while currents flowing in opposite directions cause a mutual attraction, the mask members 411a and 411c move to the right in the drawing while the mask members 411b and 411d move to the right in the drawing. As a result, the detection electrode assembly 421a is exposed while the detection electrode assembly 421b is masked. The potential of the measured object can be measured by measuring the currents flowing in the detection electrode assemblies 421a, 421b as in Example 3.

[0045]

Also in this case, it is possible, by selecting the drive frequency of the movable shutter units 410a to 410d substantially equal to a mechanical resonance frequency, to reduce an electric power required for driving.

[0046]

The present example can also provide effects similar to those of Examples 2 and 3. Also by employing two or more current generating means, it is rendered possible to dispense with the separate magnetic field generating means and to achieve a further compact structure and a lower cost in comparison with Examples 2 and 3.

[0047]

In Examples 2 to 4, leg portions of fixed member of the movable shutter unit are fixedly connected to the driving lead electrodes or the connecting electrodes, but it is also possible to form a groove portion or the like comprising a guide portion or a slide end defining portion in such electrode and to slidably fit the leg portion of the fixed member therein, whereby the movable shutter unit is rendered slidable between a masking position and an exposing position for the detection electrode. In such case the parallel hinge suspension can be dispensed with in the movable shutter unit. Such configuration can also provide similar effects.

[0048]

(Example 5)

Fig. 8 is a view showing a part of an image forming apparatus of an example 5. There are shown potential sensors 501a to 501c of the invention, a photosensitive drum 591 commonly employed in an electrophotographic process, and a charger 592. A potential distribution on the photosensitive drum 591 can be measured by monitoring outputs of the potential sensors 501a to 501c in synchronization with the rotation of the photosensitive drum 591. An unevenness in the image can be reduced by controlling an amount of light irradiating the photosensitive drum 591 or controlling the charger 592 according to thus measured

potential distribution.

[0049]

The potential sensor of the present invention, being realizable in a small dimension, can be incorporated in a plurality thereby enabling a high precise control.

[0050]

[Effect of the Invention]

As being explained so far, according to the present invention, it is rendered possible to increase the area of the detection electrode, in comparison with that in the prior potential sensor utilizing the MEMS technology. It is therefore possible to improve the sensitivity for a same dimension as in the prior technology, or to reduce the dimension for a same sensitivity as in the prior technology. It is also possible to reduce the production cost by increasing a number of sensors per a silicon wafer.

[Brief Description of the Drawings]

[Fig. 1] A plan view of a potential sensor of an example 1 of the present invention.

[Fig. 2] Views showing function of the potential sensor of the example 1.

[Fig. 3] An exploded perspective view of a potential sensor of an example 2 of the present invention.

[Fig. 4] Views showing function of the potential

sensor of the example 2.

[Fig. 5] An exploded perspective view of a potential sensor of an example 3 of the present invention.

[Fig. 6] Views showing function of the potential sensor of the example 3.

[Fig. 7] Views showing function of the potential sensor of an example 4.

[Fig. 8] A schematic view of an image forming apparatus of an example 5 of the present invention.

[Fig. 9] A view showing a general operation principle of a prior potential sensor of mechanical type.

[Fig. 10] A view showing a prior MEMS potential sensor.

[Fig. 11] A view showing drawbacks in the prior MEMS potential sensor.

[Description of Reference Numerals or Symbols]

101, 1001 Potential sensor

104, 204, 304, 1004 Substrate

110, 1010 Driver component

112, 1012 Comb-shaped electrostatic actuator

113, 1013 Movable electrode

114, 1014 Fixed electrode

118, 1018 Suspension

120, 1020 Sensor component

121a to b, 221a to b, 321a to b, 421a to b, 1021a

to c Detection electrode assembly

122a to b, 22a to b, 322a to b, 1028 Detection electrode lead electrode

124, 1024 Aperture

125, 1025 Movable shutter

150, 1050 Electrostatic drive signal source

160, 290, 390 Differential amplifier

210a to d, 310a to d, 410a to d Movable shutter unit

211a to d, 311a to d, 411a to d Mask member

212a to d, 312a to d Parallel hinge suspension

213a to d, 313a to d Fixed member

223a to b, 324a to b Driving lead electrode

230 Permanent magnet

250, 350, 450a to b Driver

323a to c Connecting electrodes

361 Coil substrate

362 Flat coil

363 Coil driver

501a to c Potential sensor

591 Photosensitive drum

592 Charger

1026 Mask portion

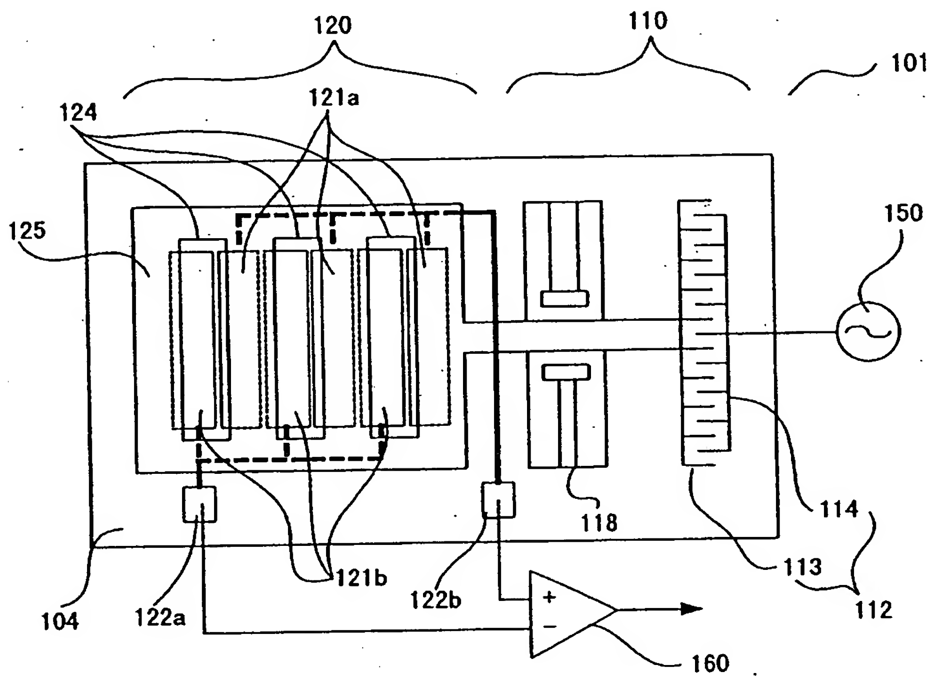
1080 Cut line

1060 Ammeter

1099 Measured object

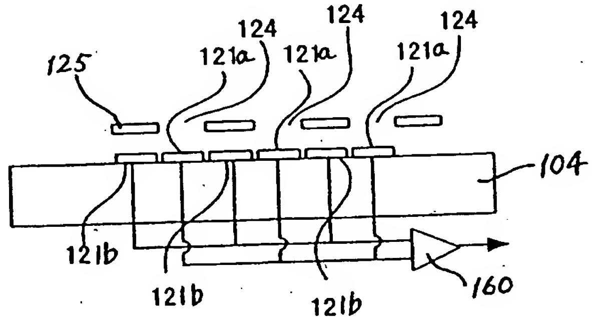
【書類名】　図面　[Name of the Document] Drawings

【図１】 Fig. 1

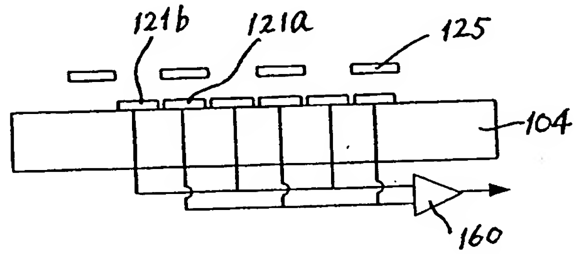


【図２】 Fig. 2

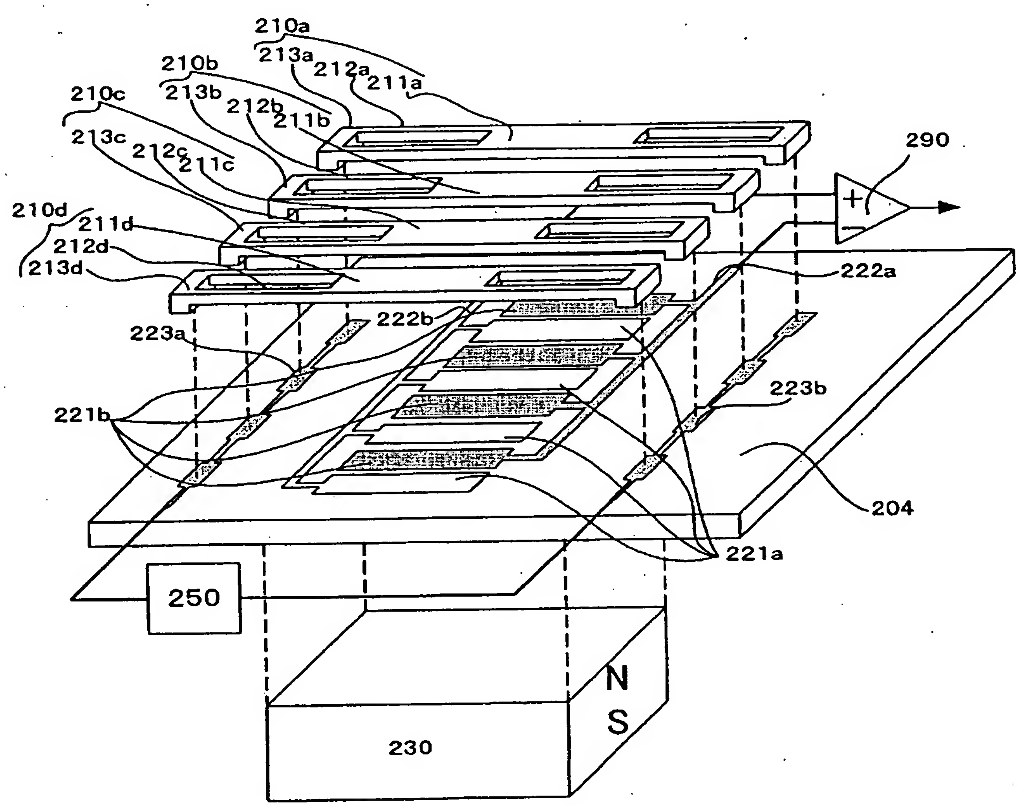
(a)


125
124
121a
124
121a
124
121a
104
121b
121b
121b
160

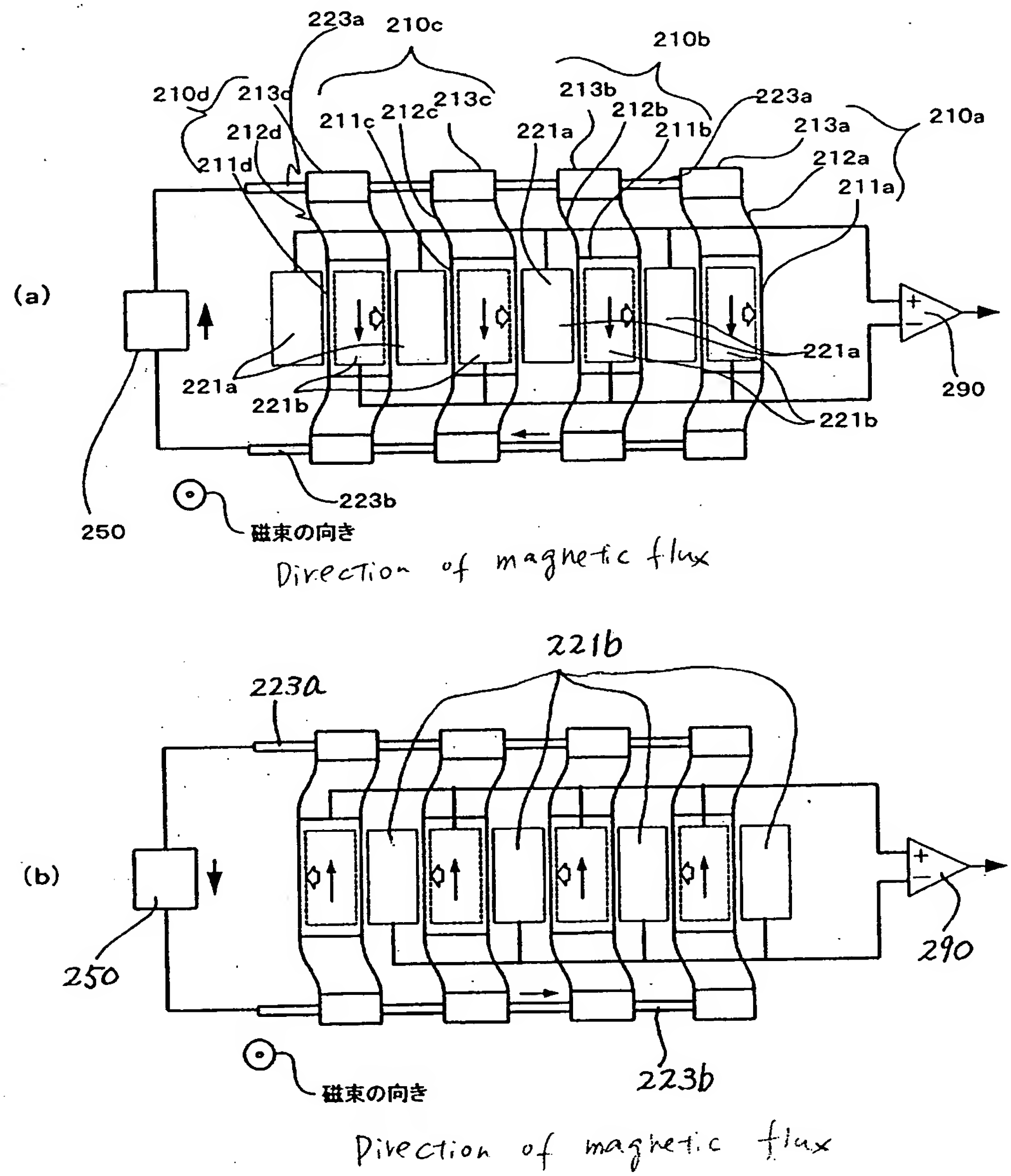
(b)


121b
121a
125
104
160

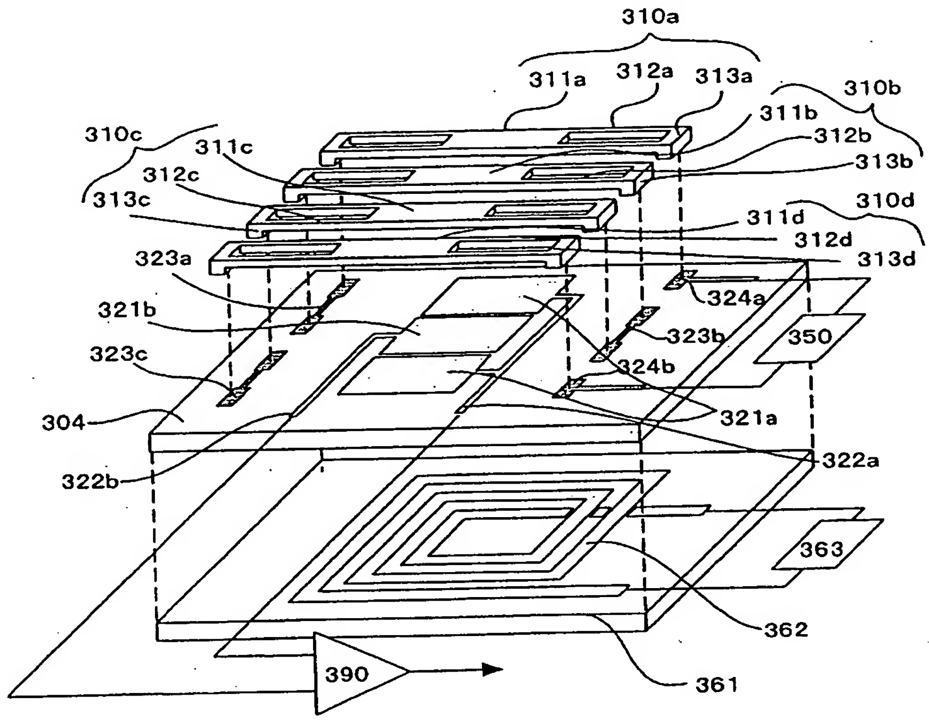
【図３】 Fig. 3


210a
213a
212a
211a
210b
213b
212b
211b
210c
213c
212c
211c
210d
211d
212d
213d
290
+
−
222a
222b
223a
223b
221b
204
221a
250
N
S
230

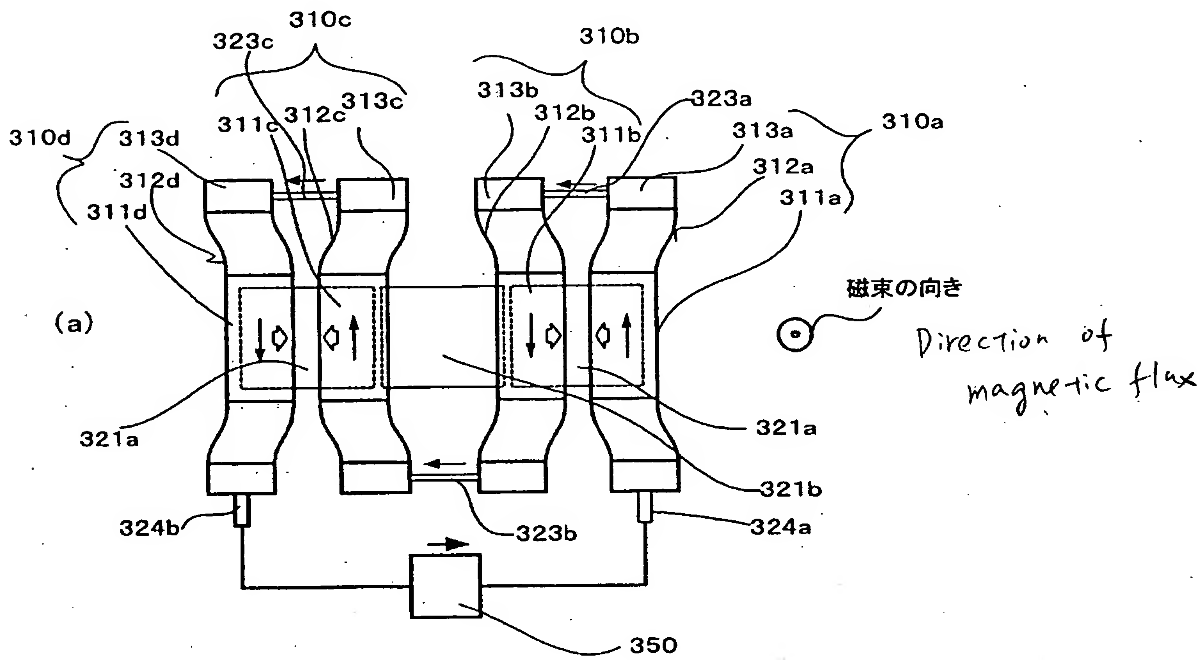
【図４】 Fig. 4

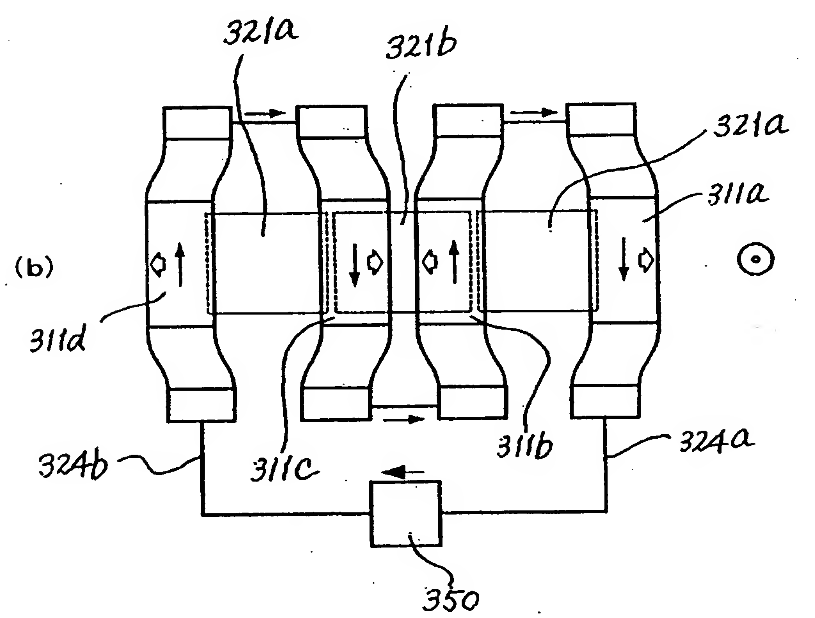

(a)
223a
210c
210b
210d
213c
213b
223a
211c
212c
213c
212b
210a
212d
221a
211b
213a
211d
212a
211a
221a
221a
290
221b
221b
250
223b
磁束の向き
Direction of magnetic flux
221b
223a
(b)
290
250
223b
磁束の向き
Direction of magnetic flux

【図５】　Fig. 5


310a
311a
312a
313a
310b
311b
312b
313b
310c
311c
312c
313c
310d
311d
312d
313d
323a
324a
321b
323b
350
323c
324b
304
321a
322a
322b
363
362
390
361

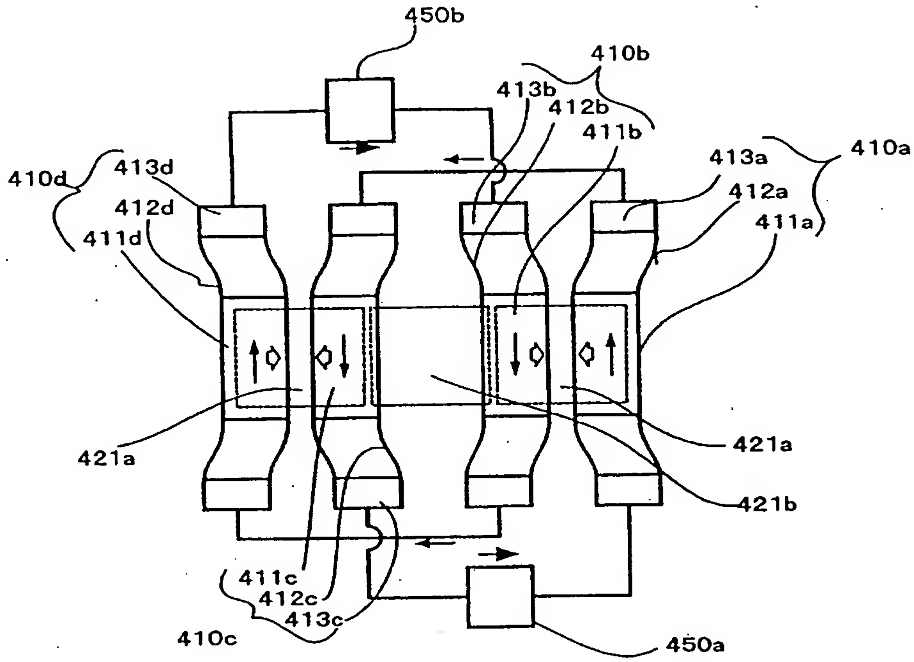
【図６】 Fig. 6


(a)
310c
310b
323c
313b
323a
312c
313c
312b
311c
311b
313a
310a
310d
313d
312a
312d
311a
311d
磁束の向き
Direction of magnetic flux
321a
321a
321b
324b
323b
324a
350

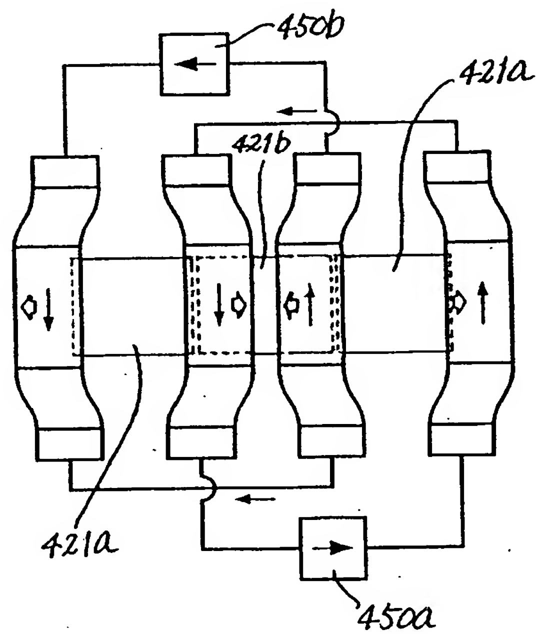

(b)
321a
321b
321a
311a
311d
324b
311c
311b
324a
350

【図７】　Fig. 7

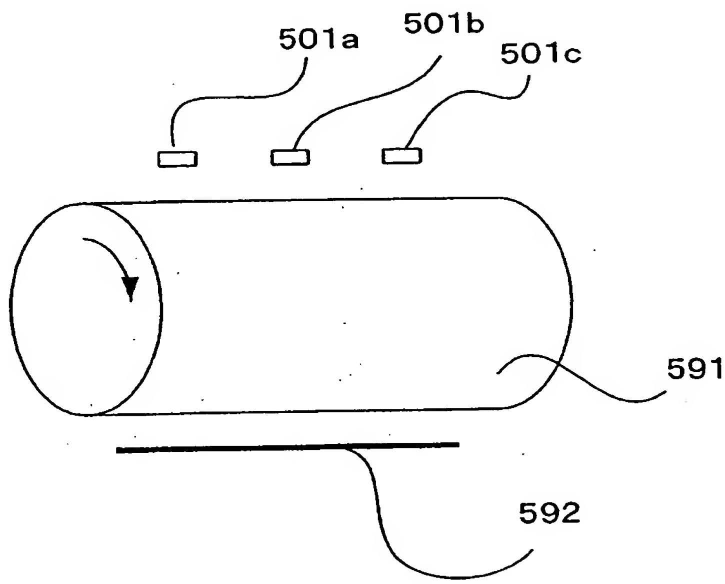
(a)


450b
410b
413b
412b
411b
410a
413a
412a
411a
410d
413d
412d
411d
421a
421a
421b
411c
412c
413c
410c
450a

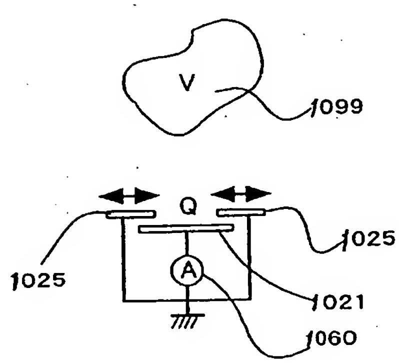
(b)


450b
421a
421b
421a
450a

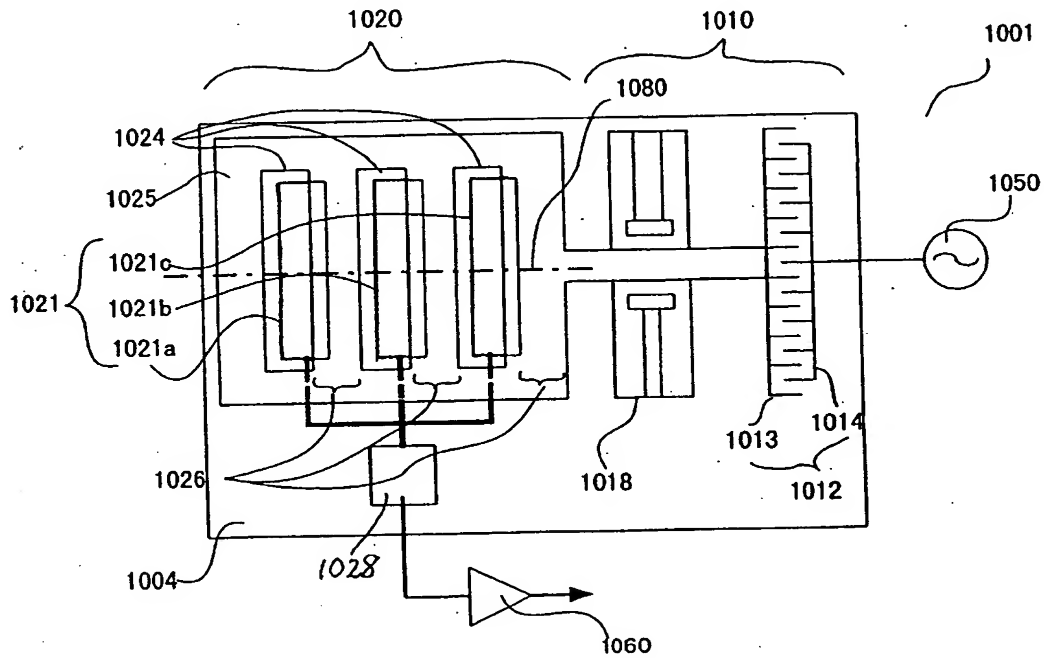
【図８】　Fig. 8



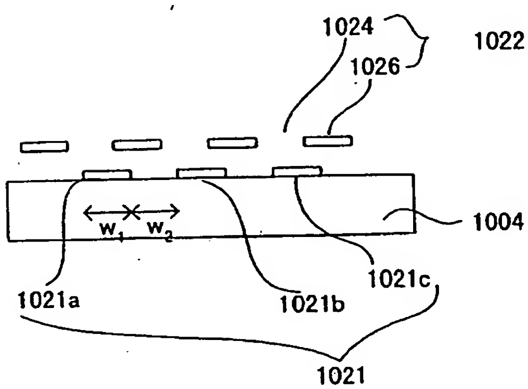
【図９】　Fig. 9



【図１０】　Fig. 10



【図１１】　Fig. 11



[Name of the Document] Abstract

[Abstract]

[Problem(s)] A potential sensor which allows to increase the effective area of the detection electrodes and to increase the sensitivity for a given size.

[Means for Solving the Problem(s)] A potential sensor 101 comprising first and second detection electrodes 121a, 121b opposed to a potential-measured object of which a potential is to be measured, a movable shutter 125 so positioned between the detection electrodes and the potential-measured object with gaps thereto when the two sets of detection electrodes 121a, 121b are opposed to the potential-measured object, and differential processing means 160 for differentially processing output from the first and second detection electrodes. The movable shutter 125 can assume two states, the first detection electrode 121a is exposed wider when the movable shutter assumes one state, and the second detection electrode 121b is exposed narrower when the movable shutter assumes another state.

[Elected Drawing] Fig. 1

2003-089465

Applicant's Information

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(Reason of Change)	New Registration
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